THE GLOBAL LAND DATA ASSIMILATION SYSTEM

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This powerful new land surface modeling system integrates data from advanced observing systems to support improved forecast model initialization and hydrometeorological investigations.

Land surface temperature and wetness conditions affect and are affected by numerous climatological, meteorological, ecological, and geophysical phenomena. Therefore, accurate, high-resolution estimates of terrestrial water and energy storages are valuable for predicting climate change, weather, biological and agricultural productivity, and flooding, and for performing a wide array of studies in the broader biogeosciences. In particular, terrestrial stores of energy and water modulate fluxes between the land and atmosphere and exhibit persistence on diurnal, seasonal, and interannual time scales. Furthermore, because soil moisture, temperature, and snow are integrated states, biases in land surface forcing data and parameterizations accumulate as errors in the representations of these states in operational numerical weather forecast and climate models and their associated coupled data assimilation systems. That leads to incorrect surface water and energy partitioning, and, hence, inaccurate predictions. Reinitialization of land surface states would mollify this problem if the land surface fields were reliable and available globally, at high spatial resolution, and in near–real time.

A Global Land Data Assimilation System (GLDAS) has been developed jointly by scientists at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) and the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Prediction (NCEP) in order to produce such fields. GLDAS makes use of the new generation of ground- and space-based observation systems, which provide

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data to constrain the modeled land surface states. Constraints are applied in two ways. First, by forcing the land surface models (LSMs) with observation-based meteorological fields, biases in atmospheric model-based forcing can be avoided. Second, by employing data assimilation techniques, observations of land surface states can be used to curb unrealistic model states.

Through innovation and an ever-improving conceptualization of the physics underlying earth system processes, LSMs have continued to evolve and to display an improved ability to simulate complex phenomena. Concurrently, increases in computing power and affordability are allowing global simulations to be run more routinely and with less processing time, at spatial resolutions that could only be simulated using supercomputers five years ago. GLDAS harnesses this low-cost computing power to integrate observation-based data products from multiple sources within a sophisticated, global, high-resolution land surface modeling framework.

What makes GLDAS unique is the union of all of these qualities: it is a global, high-resolution, offline (uncoupled to the atmosphere) terrestrial modeling system that incorporates satellite- and ground-based observations in order to produce optimal fields of land surface states and fluxes in near–real time. This article describes the major aspects of GLDAS and includes a sample of the output products. Subsequent scientific papers will present the results of several studies (now in various stages of completion) that are focusing on the data assimilation, validation, weather and climate model initialization, and other aspects of the project, in more detail than could be included in a single article.

BACKGROUND. ***Modeling of the land surface.*** Spurred by advances in the understanding of soil–water dynamics, plant physiology, micrometeorology, and the controls on atmosphere–biosphere–hydrosphere interactions, several LSMs have been developed in the past two decades with the goal of realistically simulating the transfer of mass, energy, and momentum between the soil and vegetation surfaces and the atmosphere. Currently, GLDAS drives three land surface models: Mosaic, Noah, and the Community Land Model (CLM). Additional models are slated for future incorporation, including the Variable Infiltration Capacity model (VIC; Liang et al. 1994) and the Catchment Land Surface Model (Koster et al. 2000). For a comparison of these and other LSMs, see results from the Project for Intercomparison of Land Surface Parameterization Schemes (PILPS; Henderson-Sellers et al. 1995; Bowling et al. 2003) and the Global Soil Wetness Project (GSWP; Dirmeyer et al. 1999).

MOSAIC. Mosaic (Koster and Suarez 1996) is a well-established and theoretically sound LSM with roots in the Simple Biosphere model (SiB) of Sellers et al. (1986). The primary innovation of Mosaic was its treatment of subgrid-scale variability. It divides each model grid cell into a mosaic of tiles (after Avissar and Pielke 1989) based on the distribution of vegetation types within the cell. Surface flux calculations are similar to those described by Sellers et al. (1986).

CLM. The CLM is being developed by a grassroots collaboration of scientists who have an interest in making a general land surface model available for public use (Dai et al. 2003). The project is not controlled by any single organization or scientist, rather, the science is steered by the community. CLM includes superior components from each of three contributing models: the NCAR Land Surface Model (Bonan 1998), the Biosphere–Atmosphere Transfer Scheme (BATS; Dickinson et al. 1986), and the LSM of the Institute of Atmospheric Physics of the Chinese Academy of Sciences (Dai and Zeng 1997). Both of the first two "frozen" versions of CLM are included in the GLDAS.

NOAH. Since 1993, as a core project within the Global and Energy Water Cycle Experiment (GEWEX) Continental-Scale International Project (GCIP), NCEP has spearheaded a continuing collaboration of GCIP and other investigators from both public and private institutions to develop a modern LSM to be used for operations and research in NCEP weather and climate prediction models and their data assimilation systems, and also to be supported and distributed for community usage. The Noah LSM (Chen et al. 1996; Koren et al. 1999) was borne of that effort. Noah has been used operationally in NCEP models since 1996, and it continues to benefit from a steady progression of improvements (Betts et al. 1997; Ek et al. 2003).